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(54) **POWER CONTROL IN ORTHOGONAL SUB-CHANNELS IN WIRELESS COMMUNICATIONS**

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H04W 72/04	(2009.01)

(52) **U.S. Cl.**

CPC ***H04W 52/243*** (2013.01); ***H04W 52/245*** (2013.01); ***H04W 72/0446*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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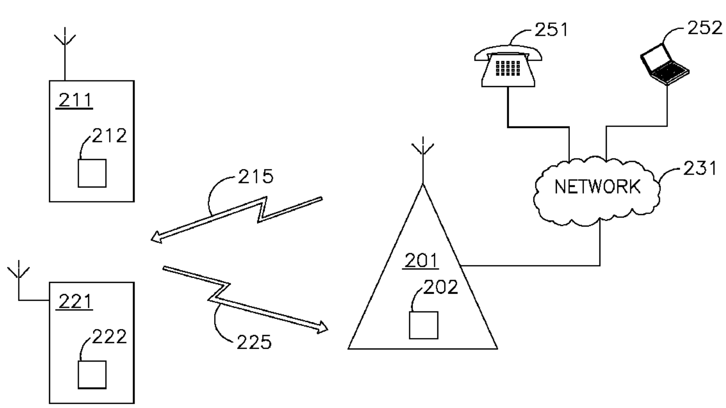
(57) **ABSTRACT**

A method and apparatus for power control in a wireless communication involves establishing at least two orthogonal sub-channels within a channel for communication and controlling transmitted power in each sub-channel independently.

15 Claims, 2 Drawing Sheets



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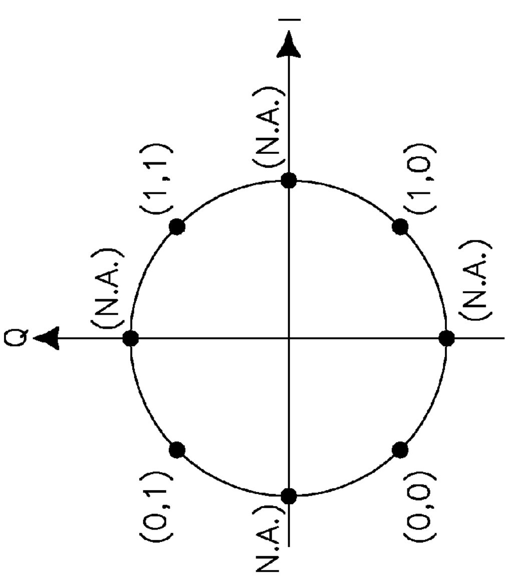
Q
I
(N.A.)
(1,1)
(1,0)
(N.A.)
(N.A.)
(0,1)
(0,0)
(N.A.)

FIG.1

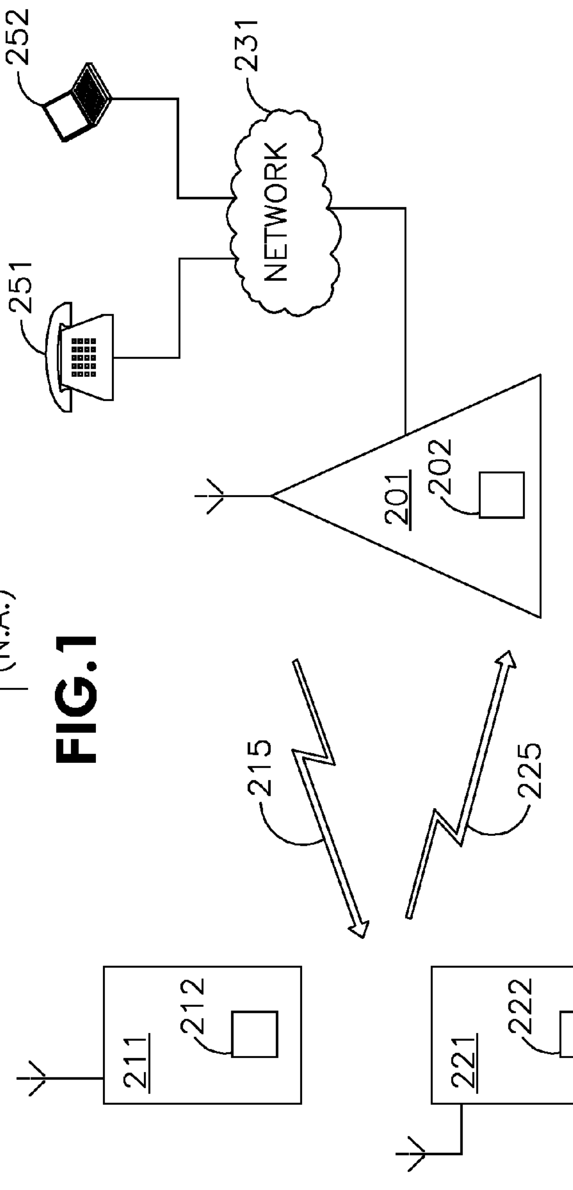
252
231
NETWORK
251
201
202
215
225
211
212
221
222

FIG.2

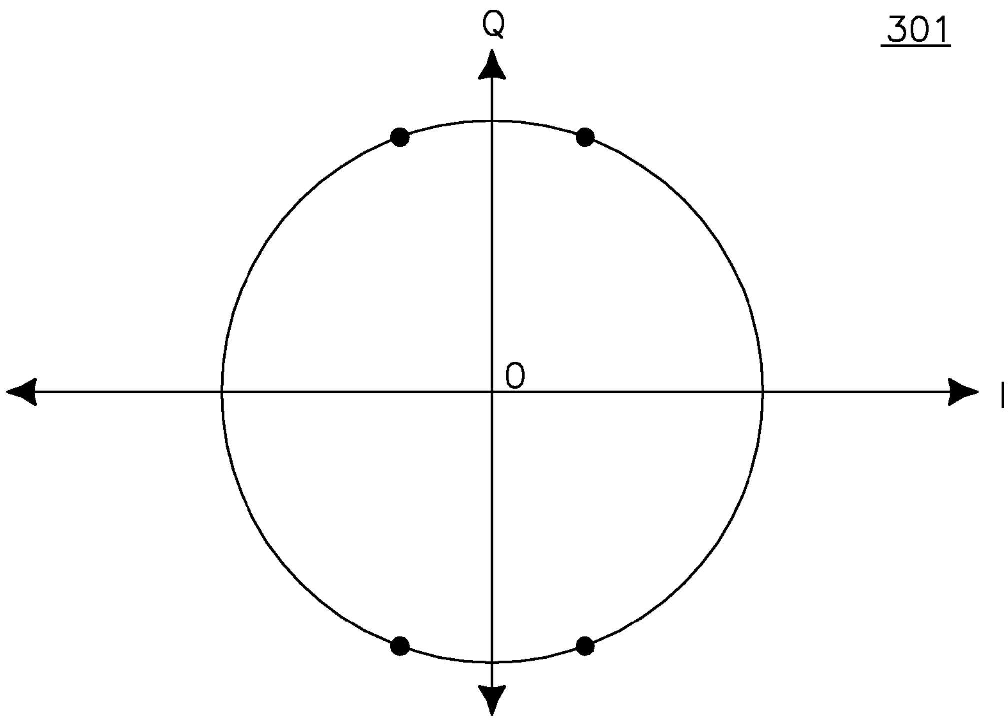

FIG.3A

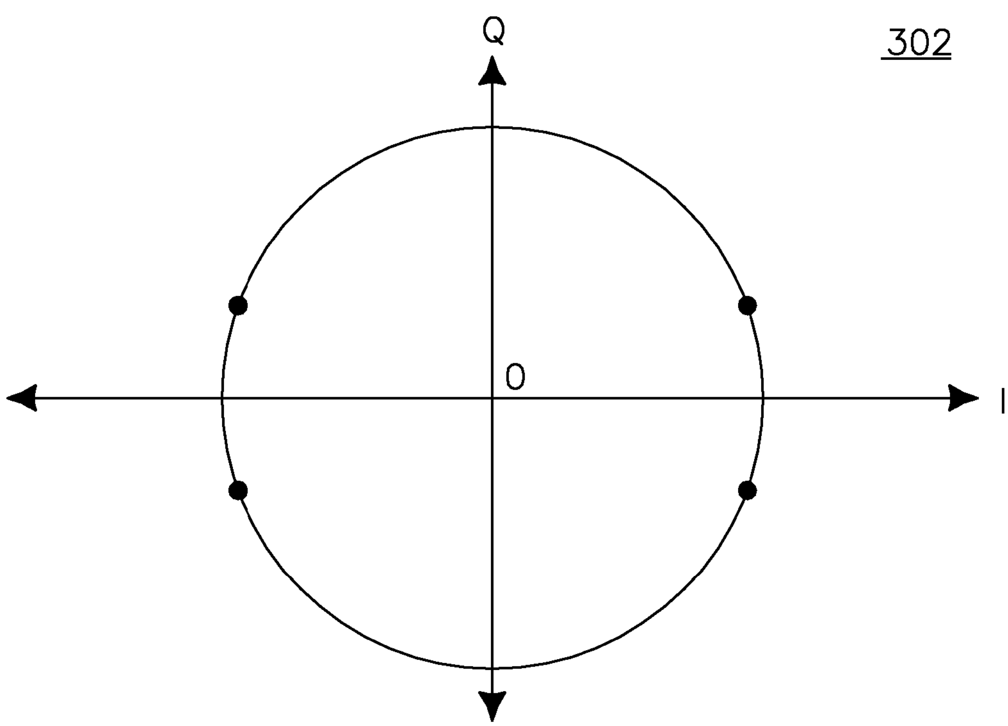

FIG.3B

POWER CONTROL IN ORTHOGONAL SUB-CHANNELS IN WIRELESS COMMUNICATIONS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 13/914,879 filed Jun. 11, 2013, which is a continuation of U.S. patent application Ser. No. 12/058,495 filed Mar. 28, 2008, which issued as U.S. Pat. No. 8,467,408 on Jun. 18, 2013, which claims the benefit of U.S. Provisional Application Ser. No. 60/909,006 filed Mar. 30, 2007, the contents of which are hereby incorporated by reference herein.

FIELD OF INVENTION

The present application is related to wireless communications.

BACKGROUND

The concept of Orthogonal Sub-channels (OSCs) and how they can be used to increase the voice capacity of GSM EDGE Radio Access Network (GERAN) cells has been disclosed by others (GSM is Global System for Mobile; EDGE is Enhanced Data rates for Global Evolution). In an OSC scheme, the base station (BS) uses Quadrature Phase-Shift Keying (QPSK) modulation for downlink (DL), which multiplexes voice data from two users. The multiplexing is done such that legacy Mobile Stations (MSs) using Gaussian Minimum Shift Keying (GMSK) can receive their respective data.

As an example, FIG. **1** shows a QPSK constellation chosen as a subset of an Eight Phase Shift Keying (8PSK) constellation. The most significant bit (MSB) and least significant bit (LSB) define two "orthogonal" sub-channels I and Q, wherein the bits are denoted as (OSC**0**, OSC**1**). Each sub-channel carries voice signals of two users in the DL direction. GMSK-only capable MSs are able to detect the individual sub-channels.

These prior OSC proposals also provide that downlink power control may use conditions of the weakest link as criteria. For example, in such an approach, if the weaker orthogonal sub-channel is I, the power control would be adjusted such that both sub-channels I and Q are equally increased until the sub-channel I attains the minimum acceptable power level. This approach would have the advantage of maintaining the shape of the QPSK constellation as circular, keeping all four constellation points equidistant, which provides maximum separation for best receiver decoding results. The disadvantage to this approach is that more power is used than is necessary on the sub-channel that is not the weakest link, (i.e., sub-channel Q in this example). Consequently, the interference between the sub-channels will increase.

SUMMARY

A method and apparatus for multi-user communication includes independent power control to each sub-channel designated to a user. A modified QPSK modulation mapping is performed for two users, each user being assigned to an orthogonal sub-channel. The power control method minimizes transmitted power on each sub-channel and interference between each sub-channel.

BRIEF DESCRIPTION OF THE DRAWINGS

A more detailed understanding may be had from the following description of a preferred embodiment, given by way of example and to be understood in conjunction with the accompanying drawing, wherein:

FIG. **1** shows a QPSK constellation chosen as a subset of an Eight Phase Shift Keying (8PSK) constellation and defining orthogonal sub-channels;

FIG. **2** shows a block diagram of a wireless communication with orthogonal sub-channel power control of a downlink signal; and

FIGS. **3**A and **3**B show orthogonal sub-channel I and Q constellations for a modified QPSK modulation with independent power control.

DETAILED DESCRIPTION

When referred to hereafter, the terminology "wireless transmit/receive unit (WTRU)" includes but is not limited to a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a computer, or any other type of user device capable of operating in a wireless environment. When referred to hereafter, the terminology "base station" includes but is not limited to a Node-B, a site controller, an access point (AP), or any other type of interfacing device capable of operating in a wireless environment.

FIG. **2** shows a base station **201**, comprising a processor **202** configured to perform a method of a first embodiment. The processor **202** processes data from users **251**, **252** via the communication network **231**, to be transmitted to a WTRU **211** and a WTRU **221** on a wireless downlink signal **215**. In order to increase capacity on the downlink signal **215**, a radio resource can be mapped by the processor **202** whereby voice or data signals from two users **251**, **252** sent in the same time slot can be individually detected by the intended receivers WTRUs **211** and **221**. A modified QPSK modulation is applied to the downlink signal **215** using orthogonal sub-channels I and Q.

FIGS. **3**A and **3**B show examples of constellations for mapping of the orthogonal sub-channels I and Q according to a modified QPSK modulation, where power control is adjusted independently on each sub-channel I and Q. In FIG. **3**A, a constellation **301** is rectangular along the Q axis, as a result of independent power adjustment upward on the sub-channel I, while applying zero power adjustment to sub-channel Q. Alternatively, there may also be some independent power control adjustment on the Q-sub-channel, so long as the relative increase in power control adjustment on the sub-channel I is greater than that on the sub-channel-Q.

Conversely in FIG. **3**B, a constellation **302** is rectangular along the I axis, which results when independent power control adjustment is increased more on the sub-channel Q than on the sub-channel I.

Alternatively, there may be a decrease in power control adjustment to either of the sub-channels I and Q.

Adaptive power control is independently applied on the sub-channels I and Q, such that the rectangular constellation of the modified QPSK modulation can vary according to an independent power control parameter α on the sub-channel I and an independent power control parameter β on the sub-channel Q. For example, the four constellation points for the modified QPSK according to this embodiment can be represented as shown in Table 1:

TABLE 1

(0, 0)	(0, 1)	(1, 0)	(1, 1)
$\alpha + j\beta$	$\alpha - j\beta$	$-\alpha + j\beta$	$-\alpha - j\beta$

The power control parameters α and β are constants set within the following limits:

$$0<\alpha\leq 1;$$

$$0<\beta\leq 1$$

where α and β are kept from approaching too close to 0. These parameters α and β represent the relative voltage amplitude for each of the two orthogonal sub-channel I and Q signals, where α is proportional to the square root of sub-channel I power P_I and β is proportional to the square root of sub-channel Q power P_Q. If the total power transmitted for the two sub-channels I and Q is equal to P, then the power P_I of the sub-channel I is as follows:

$$P_I=\alpha^2 P,$$

and the power P_Q of the sub-channel Q channel is:

$$P_Q\leq\beta^2 P.$$

Practical implementation issues may constrain the ratio of α/β to be within limits. For example, one range for the ratio may be:

$$0.5 < \frac{\alpha}{\beta} < 2,$$

which would represent a practical constraint that the relative power between the two sub-channels I and Q should not be greater than 4, or equivalently, 6 dB. The exact constraint will be a determined by practical implementation issues, including, but not limited to quantization resolution of the analog to digital process.

Thus, the example constellations shown in FIGS. **3**A and **3**B each depict one of many possible variations, depending on the power control parameter selected. The processor **202** determines the power control parameters α and β depending on detected received channel quality according to typical power control feedback schemes. One example includes the processor **212** of WTRU **211** determining that the multiple errors have been detected on received signal **215**, and in response, a channel quality indicator (CQI) is reported back to the base station **201**. Based on the CQI, the processor **202** of base station **201** will select a power control parameter α that will independently increase power on the sub-channel I, which was allocated for the WTRU **211**.

Various power control techniques can be applied to the orthogonal sub-channels I and Q, including open-loop based or close-loop based schemes. Also, the time scale of the power control adaptation may be optimally chosen. The criteria for power control adaptation may include signal power, noise, or interference levels in any combination.

The criteria for power control adaptation also takes into account dynamic range issues. For example, measures are taken to ensure that the two sub-channels I and Q are sufficiently close in power level to prevent the well-known signal capture problems that can occur when a receiver, such as the WTRU **211**, must process two signals arriving at significantly different power levels. In particular, the capture problems can occur at the WTRU **211** receiver during A/D conversion, where an A/D converter dynamic range can be impacted by a large power level offset between received sub-channels I and Q. Maintaining a proper balance of the power levels can be achieved by the following two techniques, either alone or in a combination thereof: (1) during a scheduling and channel assignment process, avoid assigning the two sub-channels I and Q to the WTRUs **211** and **221** with excessive differences in required transmit power level; and (2) set the individual target power levels to values that support a proper balance. Optionally, an additional, larger dynamic range can be achieved by specifying an increased dynamic range capability for the mobile terminals (i.e. more bits in the A/D converter).

As part of the OSC modulation applied by the base station **201**, a link adaptation is performed for multiplexing the receivers WTRU **211** and WTRU **221**, by which the base station **201**, or a Base Station System (BSS) to which it belongs, can dynamically change the multiplexing based on current channel conditions. Take for example, a scenario in which the WTRU **211** is located very close to the base station **201**, and the WTRU **221** is located relatively further away from the base station **201**, and the sub-channels are multiplexed to the same time slot. Using internal thresholds and hysteresis, the base station **201** may elect to reassign the WTRU **221** information from the multiplexed time slot and instead multiplex the WTRU **211** information with information of another WTRU that is located closer to the base station **201**. This can be achieved by simple Intra-Cell Handover procedures, taking advantage of procedures such as "Packing/Unpacking". As an alternative option, the base station **201** may elect to have the WTRU **221** as the sole user of another time slot.

The modified QPSK modulation method described above relates to the packet-switched (PS) domain as follows. In PS domain, data is exchanged on channels, such as a Packet Data Channel (PDCH). An example of a PDCH is a time slot in a single carrier. The timeslot carries a radio burst, which is made up of a number of modulated symbols, each of which carries one or more bits of data. All of these bits belong to the PDCH. In the present context, the bits associated with each symbol in the downlink are assigned to multiple users, such as the WTRU **211** and the WTRU **221**. For example, the MSB and LSB of the modified QPSK (i.e., (MSB, LSB)) may be assigned as follows: MSB to the WTRU **211**, LSB to the WTRU **221**. Correspondingly, in the uplink, the WTRU **211** and the WTRU **212** transmit on the same time slot and the same carrier frequency, but using different (preferably orthogonal) training sequences. In this embodiment, the definition of the PDCH is extended to such orthogonal sub-channels, referred to herein as Orthogonal-PDCH (O-PDCH). In the above example, two O-PDCHs are defined in terms of the two orthogonal sub-channels in both the downlink and the uplink.

As an implementation of this embodiment, the WTRU **211** or the WTRU **221** may receive a Packet Timing Control Channel (PTCCH) using an orthogonal sub-channel I or Q in the downlink. One advantage to this is that there would be no need for the base station **201** to allocate a separate channel for the PTCCH, and delay transmission of PTCCH information until an opportunity is available for the PTCCH transmission. Instead, the PTCCH information can be conveyed immediately on the I and Q sub-channels and received by the WTRU **211**, **221** without delay. For uplink transmissions by the WTRU **211** and **221**, a normal PDCH may be used, (e.g., for case where WTRUs **211**, **221** are legacy devices). Alternatively, an O-PDCH may be defined for the uplink, by which each of the sub-channels I and Q could carry a different data stream, or one sub-channel could carry data information and the other could carry voice or control information.

In an O-PDCH made up of more than one time slot, one or more time slots may carry orthogonal sub-channels I and Q, whereas other time slots support normal PDCH channels.

In order to uniquely identify the multiplexed WTRU **211** from the WTRU **221** in the downlink **215**, the base station **201** can send two different blocks of information, using the sub-channels I and Q, respectively to the WTRU **211** and the WTRU **221**. Within the same time slot, each block of information contains a Temporary Flow Identity (TFI) in the header that corresponds to the sub-channel I or Q.

Within an uplink **225** signal, the WTRU **211** can be uniquely identified from the WTRU **221** by scheduling of resources based on an uplink state flag (USF) parameter and/or the TFI. The scheduling of resources can be performed by the base station **201** using the orthogonal sub-channels I and Q to send two different USF values, one on each sub-channel, to the WTRU **211** and WTRU **221**. When the WTRU **211** and WTRU **221** send information in the uplink, they are uniquely identified by a unique mapping of their corresponding TFI and the sub-channel number (e.g., **0** or **1**). The base station processor **202** detects the unique TFI and sub-channel number on the received uplink, enabling unique identification of the WTRU **211** and WTRU **221** signals.

Finally, link adaptation can be applied to each O-PDCH by changing adaptively among various modulation and coding scheme (MCS) classes. Automatic Repeat Request (ARQ) with and without incremental redundancy can be applied for reliable transmission of data.

While embodiments have been described in terms of QPSK modulation, other possible variations may apply higher order modulations including, but not limited to 8PSK, 16QAM and 32QAM, whereby the constellations may reflect independent power control of sub-channels according to power control parameter selection and adjustment.

Although features and elements are described above in particular combinations, each feature or element can be used alone without the other features and elements or in various combinations with or without other features and elements. The methods or flow charts provided herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable storage medium for execution by a general purpose computer or a processor. Examples of computer-readable storage mediums include a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs).

Suitable processors include, by way of example, a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), and/or a state machine.

A processor in association with software may be used to implement a radio frequency transceiver for use in a wireless transmit receive unit (WTRU), user equipment (UE), terminal, base station, radio network controller (RNC), or any host computer. The WTRU may be used in conjunction with modules, implemented in hardware and/or software, such as a camera, a video camera module, a videophone, a speakerphone, a vibration device, a speaker, a microphone, a television transceiver, a hands free headset, a keyboard, a Bluetooth® module, a frequency modulated (FM) radio unit, a liquid crystal display (LCD) display unit, an organic light-emitting diode (OLED) display unit, a digital music player, a media player, a video game player module, an Internet browser, and/or any wireless local area network (WLAN) or Ultra Wide Band (UWB) module.

What is claimed is:

1. A method for use in a first wireless transmit/receive unit (WTRU), for detecting transmissions for one of a plurality of users on a same physical resource, the method comprising:

receiving, by the first WTRU, on a physical resource in a same time slot, a first data for the first WTRU via a first one of in-phase and quadrature phase sub-channels on the physical resource and a second data for a second WTRU via a second one of in-phase and quadrature phase sub-channels on the same physical resource, wherein a transmit power of the in-phase sub-channel and a transmit power of the quadrature phase sub-channel are independent of each other;

processing, by the first WTRU, the first data; and

not processing, by the first WTRU, the second data.

2. The method of claim **1** wherein a ratio of the transmit power between the in-phase and quadrature phase sub-channels is within a predetermined range.

3. The method of claim **1**, wherein the transmit power on the in-phase and quadrature phase sub-channels is based on at least one of a signal power level, a noise level, and an interference level on each sub-channel.

4. The method of claim **1** wherein a target power value is set for the in-phase and quadrature phase sub-channels, respectively, to support a power balance between the in-phase and quadrature phase sub-channels.

5. The method of claim **1** wherein the physical resource is a time division multiple access (TDMA) resource.

6. A first wireless transmit/receive unit (WTRU) for detecting transmissions for one of a plurality of users on a same physical resource, comprising:

a transceiver operatively coupled to a processor, the transceiver configured to receive on a physical resource in a same time slot, a first data for the first WTRU via a first one of in-phase and quadrature sub-channels on the physical resource and a second data for a second WTRU via a second one of in-phase and quadrature sub-channels on the same physical resource, wherein a transmit power of the in-phase sub-channel and a transmit power of the quadrature sub-channel are independent of each other;

the processor configured to process the first data; and

the processor configured to not process the second data.

7. The WTRU of claim **6** wherein a ratio of the transmit power between the in-phase and quadrature phase sub-channels is within a predetermined range.

8. The WTRU of claim **6** wherein the transmit power on the in-phase and quadrature phase sub-channels is based on at least one of a signal power level, a noise level, and an interference level on each sub-channel.

9. The WTRU of claim **6** wherein a target power value is set for the in-phase and quadrature phase sub-channels, respectively, to support a power balance between the in-phase and quadrature phase sub-channels.

10. The WTRU of claim **6** wherein the physical resource is a time division multiple access (TDMA) resource.

11. A method for use in a second wireless transmit/receive unit (WTRU), for detecting transmissions for one of a plurality of users on a same physical resource, the method comprising:

receiving, by the second WTRU, on a physical resource in a same time slot, a first data for a first WTRU via a first one of in-phase and quadrature phase sub-channels on the physical resource and a second data for the second WTRU via a second one of in-phase and quadrature phase sub-channels on the same physical resource, wherein a transmit power of the in-phase sub-channel and a transmit power of the quadrature phase sub-channel are independent of each other;

processing, by the second WTRU, the second data; and

not processing, by the second WTRU, the first data.

12. The method of claim **11** wherein a ratio of the transmit power between the in-phase and quadrature phase sub-channels is within a predetermined range.

13. The method of claim **11**, wherein the transmit power on the in-phase and quadrature phase sub-channels is based on at least one of a signal power level, a noise level, and an interference level on each sub-channel.

14. The method of claim **11** wherein a target power value is set for the in-phase and quadrature phase sub-channels, respectively, to support a power balance between the in-phase and quadrature phase sub-channels.

15. The method of claim **11** wherein the physical resource is a time division multiple access (TDMA) resource.

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